

Production of Butter Incorporated with Hazelnut Powder

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ABSTRACT

World consumption of butter has declined over the last decades partly due to its physical limitations and partly due to its poor nutritional properties. In this study, the effect of hazelnut addition on the properties of butter, was evaluated taking into account that hazelnut is a source of unsaturated fatty acids and antioxidants. Powdered hazelnut was added to butter at 3 levels (10, 20 and 30 percent w/w). The butter samples were then kept in refrigerator for 4 weeks. The acid and peroxide values, oxidative stability, fatty acid profile, tocopherol content as well as sensory characteristics of hazelnut added butter samples were determined and compared with those of control as during cold storage. Results revealed that hazelnut fortified butter samples bore higher acid values vs. lower peroxide value, as well as oxidative stability values than the control samples. Both acid values, and peroxide values increased in all the samples throughout storage. The concentration of unsaturated fatty acids, including essential fatty acids were recorded as significantly higher ($P < 0.05$) in the fortified butter samples. The contents of α - and γ, β -tocopherol were also higher for the fortified samples, however, their levels especially the level of α -tocopherol, decreased during storage. Sensory evaluation showed no significant difference ($P > 0.05$) between fortified vs. control samples in terms of either the overall acceptance or any undesirable flavor characteristics. This study introduces a new functional dairy product that can be a step forward towards the modification of butter nutritional drawbacks through an increase in its essential fatty acids as well as antioxidant constituents.

Keywords: Butter, Fatty acids, Hazelnut, Sensory characteristics, Tocopherol.

INTRODUCTION

World consumption of butter has steadily declined over the last two decades due to many factors including butter inherent physical limitations and its poor nutritional properties (high levels of saturated fatty acids and cholesterol) (Marangoni and Rousseau, 1998; Makhlof *et al.*, 1987). Dietary intake of cholesterol may be one of the factors

contributing to the elevation of serum cholesterol beside high total and saturated fat, low dietary fiber intake and high-serum cholesterol, especially Low-Density Lipoproteins (LDLs), which is one of the risk factors associated with atherosclerosis (Hettinga, 2005).

Therefore, any attempt to modify the fatty acids profile in butter with no any effective loss in its sensory characteristics would be highly helpful. As a result, efforts to improve butter nutritional values have resulted in a

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number of such techniques for chemical, physical and enzymatic modification of butter, as fractionation, chemical and enzymatic interesterification, hydrogenation and blending. However, such drawbacks as high cost of fractionation, a loss of the flavor of butter under the conditions normally used for chemical interesterification (Wright and Marangoni, 2006) as well as the production of some trans fatty acids during hydrogenation (Kaylegian *et al.*, 1993) have limited the application of these methods. Among the studied methods, blending seems to be the cheapest way of modifying oil and fat properties (Greyt and Dijkstra, 2008) and many studies have been carried out on blending of either milk fat or butter with other edible oils and fats, vegetable extracts, surfactants, and/or polyphenolic compounds, etc (Ahmed *et al.*, 1979; Zegarska *et al.*, 1998; Ayar *et al.*, 2001; Kolanowski *et al.*, 2001; Wojdyło *et al.*, 2005; Rodrigues *et al.*, 2007; Gramza-Michalowska *et al.*, 2007).

Nuts form part of such healthy diets as the Mediterranean diet. Mortality rates from Coronary Heart Disease (CHD) and cancers are low in the traditional Mediterranean population. Results from several epidemiological studies suggest that there may be a connection between frequent nut consumption and a reduced incidence of CHD (Kornsteiner *et al.*, 2006). On the other hand, in spite of the high fat content of nuts, an inverse or no relationship has been suggested between nut consumption and BMI (indirect measure of body fatness) in the US population (Sabate, 2003). These positive health effects of nuts have been reasonably attributed to their composition of vitamins, minerals, mono- and poly-unsaturated fatty acids, fiber, phenols (particularly flavonoids), as well as phytosterols (Chen and Blumberg, 2008).

Among nut species, hazelnut is widely appreciated. Besides being consumed as a fruit, it is also consumed in a diversity of such manufactured food products, as snacks, chocolates, cereals, bakery, dairy, salad, entree, sauce, ice creams, and other dessert formulations due to the recognition of its nutritional and nutraceutical properties (Ozdemir and Akinci, 2004). Hazelnut plays a major role in human nutrition and health

because of its special composition of fat (around 60%), most of which is highly rich in MonoUnsaturated Fatty Acids (MUFA) (mainly oleic acid) (Alasalvar *et al.*, 2006). It also contains high levels of phytosterols (117-124 mg 100 g⁻¹) (Phillips *et al.*, 2005) with β -sitosterol having been known as the main sterol (about 80%) in some different varieties of hazelnut (Amaral *et al.*, 2006). Phytosterols, due to their structural similarity with cholesterol, inhibit its intestinal absorption, thereby lowering the total plasma cholesterol as well as LDL levels. They may also provide protection from colon, breast, and prostate cancers (Amaral *et al.*, 2003). Hazelnut oil is an excellent source of vitamin E (41.92 mg 100 g⁻¹) with α -tocopherol as the most dominant form of vitamin E too. Consuming approximately 24 g of hazelnut oil per day has been demonstrated to supply 100% of the Recommended Dietary Allowance (RDA) of vitamin E for adults (Alasalvar *et al.*, 2006). Squalene is another antioxidant compound existing in hazelnut in high concentrations (186.4 μ g g⁻¹ oil) (Maguire *et al.*, 2004). It has such important beneficial effects on health, as decreasing the risk of various cancers and as well a reduction in serum cholesterol levels. It has also been demonstrated to be an efficient quencher of singlet oxygen (Kohnno *et al.*, 1995). Therefore, fortification of butter with such nuts as hazelnut may possibly lead to a novel product rich in phytochemicals, beneficial to human health.

The aim of the present study was to investigate the effects of ground hazelnut addition on the chemical and sensory characteristics, fatty acid profile and tocopherol content of butter. To the best of our knowledge, there is no information so far available in literature on the fortification of butter with hazelnut for an improvement of its nutritional properties.

MATERIALS AND METHODS

Hazelnut was purchased from local market and milled into fine powder. Hazelnut powder was added at three levels (10, 20 and 30% w/w) to commercial butter (Shakelli, Tehran, Iran), collected soon and directly

after being made. Butter samples were then blended with powders for 20 minutes at 20 °C until homogenous samples were obtained. Samples were then packaged and stored at 4 °C in refrigerator for up to 4 weeks prior to analysis. All the samples were prepared in triplicate with all the experiments for each sample also analysed in triplicate.

Acid and Peroxide Values (PV)

Acid and peroxide values were evaluated according to the AOAC method (AOAC, 2005).

Oxidative Stability

Oxidative stability of butter samples were determined by Rancimat (Metrohm 743 Rancimat; Metrohm, Riverview, FL, USA) according to the method described by Tabee *et al.* (2008a).

Analysis of Fatty Acid Composition

For a determination of fatty acids' composition, Fatty Acid Methyl Esters (FAMES) of samples were prepared according to the method described by Dutta *et al.* (1994). GC analyses of FAMES were then performed using a Chrompack CP 9001 gas chromatograph (Chrompack, Middelburg, The Netherlands). The GC was equipped with a flame ionization detector and split/splitless injector. A 60 m (length), 0.25 μm (diameter) and 0.25 μm (film thickness) fused-silica capillary column BPX70 (SGE, Austin, TX, USA) was made use of in the analysis. Injector and detector temperatures were set at 210 and 240 °C, respectively. Oven conditions were 80 °C increased to 200 °C at a rate of 15 °C min^{-1} , maintained for 10 minutes and then raised to 220 °C at a rate of 30 °C min^{-1} and maintained for 5 minutes. Helium was utilized as a carrier gas and nitrogen as a make-up gas at a flow rate of 1 ml min^{-1} . FAMES were

identified by a comparison of their retention time with standard FAMES. The peak areas were integrated through Maestro version 2.4 (Chrompack, Middelburg, The Netherlands) and reported as a percentage of total fatty acids (Azadmard-Damirchi and Dutta, 2008).

Tocopherol Content

Tocopherol content of the butter samples was determined through HPLC (Cecil Instruments Ltd., Cambridge, England) according to the method described by Fathi-Achachlouie and Azadmard-Damirchi (2009), and Tabee *et al.* (2008a, b).

Sensory Analysis

Fourteen trained panelists (6 females, 8 males, age 20-33) were invited. Samples were cut into 2.54 cm^2 cubes and placed in refrigerator for at least 2 hours before being served. Butter samples were served monadically in individual booths, in foam cups labeled with 3 digit numbers. Panelists were instructed to have their mouths rinsed with spring water and have their palates cleansed with unsalted crackers before tasting each sample and to expectorate all the water and butter. Each panelist was given 3 samples and each sample evaluated 6 times by the panelists. Flavor attributes were rated between 1 and 10 while the textural and apparent attributes rated between 1 to 5 scores.

Consumer acceptance was also determined by asking untrained volunteers to indicate their degree of liking on a 9 point scale (1= Dislike extremely to 9= Like extremely). Panelists were instructed to have their mouths rinsed before each sample. Serving order was randomized.

Statistical Analysis

A Complete Randomized Design (CRD) using SAS software was performed. ANOVA was carried out to evaluate the



effect of nut concentrations (0, 10, 20 and 30%) and storage time (0, 2 and 4 weeks). Tukey test was employed to compare significant differences ($P < 0.05$) between means.

RESULTS AND DISCUSSION

Acid and Peroxide Values

Variations in acid and peroxide values of butter samples during storage are presented in Table 1. The results indicate that an increase in the concentration of hazelnut in butter led to a significant increase ($P < 0.05$) in acid value. Moreover, acid values of butter samples increased, upon storage period, at a rising trend which was higher for the fortified samples. These results concur with previous research findings (Ahmed *et al.*, 1979; Mallia, 2008). Ahmed *et al.* (1979) investigated butter samples enriched with refined soya and with cottonseed oils and reported that an increase in the added oil caused an increase in acid value of the enriched samples. Also, Mallia (2008) investigated the free fatty acids of butter samples fortified with Unsaturated Fatty Acid/Conjugated Linoleic Acid (UFA/CLA) and showed that the index of lipolysis, defined as the sum of C6:0 to C20:0 fatty acids, was significantly higher in UFA/CLA incorporated butter. Increased acid value of fortified samples in this study might be due to the hydrolytic rancidity arising from

inherent lipolytic activity of hazelnut. Also, butter is a water in oil emulsion containing about 16% water which could contribute to lipolytic rancidity.

Butter samples showed different patterns in terms of *PV* as compared with acid value. Nut fortified samples showed significantly ($P < 0.05$) lower *PVs* than control butter, which might be due to the presence of such antioxidant compounds as tocopherols, phytosterols and squalene at their high levels in hazelnut (Phillips *et al.*, 2005; Alasalvar *et al.*, 2006; Maguire *et al.*, 2004). Moreover, *PV* of samples increased during storage time and it happened more rapidly in control butter than in the fortified samples. Nevertheless, *PV* in both fortified and control samples did not exceed the standard limit ($1 \text{ meq O}_2 \text{ kg}^{-1}$). The observed increase in *PV* during storage is due to the autocatalytic nature of the lipid oxidation reaction (Fox and McSweeney, 1998).

Fatty Acid Composition

Results showed that fortification of butter with hazelnut powder could increase unsaturated fatty acids, especially oleic acid, the main fatty acid in hazelnut (Table 2). There is evidence that a MUFA rich diet can lower the risk of CHD and it also benefits from preventive effects as regards atherosclerosis (Amaral *et al.*, 2006). Also, epidemiological and clinical trials suggest that omega-3 PUFAs might have a

Table 1. Acid and peroxide values of butter samples.^a

| Properties | Storage time (Week) | Samples | | | |
|----------------------------------------------------------|------------------------|--------------------------|---------------------------------|---------------------------|--------------------------|
| | | Control | Samples fortified with hazelnut | | |
| | | | 10% | 20% | 30% |
| Acid value (% oleic acid) | 0 | 0.28±0.00 ^{b A} | 0.32±0.00 ^{b A} | 0.38±0.00 ^{ab A} | 0.44±0.01 ^{a A} |
| | 2 | 0.28±0.01 ^{c A} | 0.46±0.07 ^{b B} | 0.60±0.01 ^{a B} | 0.69±0.00 ^{a B} |
| | 4 | 0.31±0.00 ^{c A} | 0.63±0.00 ^{b C} | 0.90±0.02 ^{a C} | 1.00±0.01 ^{a C} |
| Peroxide value (meq O ₂ kg ⁻¹) | 0 | 0.35±0.01 ^{a A} | 0.08±0.01 ^{b A} | 0.10±0.00 ^{b A} | 0.11±0.00 ^{b A} |
| | 2 | 0.48±0.03 ^{a B} | 0.08±0.00 ^{b A} | 0.11±0.01 ^{b A} | 0.11±0.02 ^{b A} |
| | 4 | 0.67±0.02 ^{a C} | 0.09±0.02 ^{b A} | 0.11±0.00 ^{b A} | 0.12±0.00 ^{b A} |

^a Different small letters within the same row indicate significant difference ($P < 0.05$) and different capital letters within the same column indicate significant difference ($P < 0.05$).

Table 2. Fatty acid profile of butter samples (%).^a

| Fatty acids | Samples | | | | |
|-------------|--------------|-------------------------|---------------------------------|--------------------------|-------------------------|
| | Hazelnut oil | Control | Samples fortified with hazelnut | | |
| | | | 10% | 20% | 30% |
| 14:0 | 0.2 | 16.15±0.07 ^a | 14.80±0.42 ^b | 12.90±0.00 ^c | 11.25±0.07 ^d |
| 16:0 | 8.5 | 34.05±0.21 ^a | 31.15±0.07 ^b | 28.05±0.21 ^c | 24.15±1.49 ^d |
| 18:0 | 2.9 | 9.30±0.14 ^a | 8.51±0.13 ^b | 7.39±0.24 ^c | 6.77±0.14 ^d |
| 18:1 | 77.7 | 15.60±0.14 ^c | 18.86±1.46 ^{bc} | 22.88±3.83 ^{ab} | 25.73±4.59 ^a |
| 18:2 | 10.0 | 1.15±0.07 ^a | 1.59±0.14 ^a | 2.04±0.22 ^a | 2.43±0.23 ^a |
| 18:3 | 0.1 | 0.61±0.01 ^a | 0.55±0.01 ^{ab} | 0.46±0.03 ^{ab} | 0.41±0.02 ^c |

^a Different letters within the same row mean significant difference (P< 0.05)

significant role in the prevention of CHD through several mechanisms including antiarrhythmic, hypolipidemic, and antithrombotic roles (Amaral *et al.*, 2003).

On the other hand, the amount of saturated fatty acids showed significant decreases (P< 0.05) upon addition of hazelnut powder (Table 2). Increased level of unsaturated fatty acids in fortified samples is due to the predominance of these fatty acids in hazelnut. Mallia *et al.* (2008) showed that compared with conventional butter, the UFA/CLA enriched butter had significantly higher concentrations of MUFAs (30%) and PUFAs (33%).

Moreover, fatty acid composition of hazelnut oil extracted from hazelnuts used in this study was determined. The predominant fatty acid in the analyzed hazelnut oil sample was oleic acid (77.7%), followed by linoleic acid (10%), which justifies the results obtained from the fatty acid composition of hazelnut incorporated butter samples (Table 2). This result concurs with

the previously obtained results by Maguire *et al.* (2004).

Tocopherol Content

The content of individual tocopherols varied significantly (P< 0.05) among butter samples (Table 3). Control butter carried low levels of α -tocopherol; with no γ -tocopherol being detected. Fortified samples carried higher levels of both α -tocopherol (increased by 46, 90 and 110% in samples fortified with 10, 20 and 30% hazelnut, respectively) and γ -tocopherol (as compared with control) their levels being increased by increase in the content of added hazelnut. High tocopherol content of fortified samples could be one of the reasons for the lower PV of hazelnut added butter as compared with control (Table 1). Moreover, the fortified samples carried a higher content of α - than γ -tocopherol, which is attributed to the predominance of α -tocopherol in hazelnut (Maguire *et al.*, 2004), confirmed by the

Table 3. Tocopherol content of butter samples (mg 100 g⁻¹).^a

| Tocopherols | Storage time (Week) | Samples | | | | |
|-----------------------------|---------------------|--------------|------------------------|---------------------------------|------------------------|------------------------|
| | | Hazelnut oil | Control | Samples fortified with hazelnut | | |
| | | | | 10% | 20% | 30% |
| α -tocopherol | 0 | 31.62 | 2.95±0.02 ^d | 4.32±0.06 ^c | 5.63±0.10 ^b | 6.71±0.1 ^a |
| | 2 | - | 2.93±0.01 ^d | 4.27±0.09 ^c | 5.54±0.07 ^b | 6.55±0.0 ^a |
| | 4 | - | 2.92±0.02 ^d | 4.23±0.08 ^c | 5.45±0.04 ^b | 6.39±0.3 ^a |
| γ, β -tocopherol | 0 | 4.55 | Nd ^d | 0.22±0.01 ^c | 0.46±0.01 ^b | 0.69±0.01 ^a |
| | 2 | - | Nd ^d | 0.22±0.00 ^c | 0.46±0.00 ^b | 0.68±0.00 ^a |
| | 4 | - | Nd ^d | 0.22±0.02 ^c | 0.45±0.04 ^b | 0.68±0.02 ^a |

^a Different letters within the same row indicate significant difference (P< 0.05), Nd: Not detected.



analysis of the tocopherol content of hazelnut oil extracted from the very hazelnuts added to the butter samples (Table 3).

Tocopherol content of butter samples, especially α -tocopherol, decreased during the four weeks of storage (1, 3, 6 and 11% in control sample and samples fortified with 10, 20 and 30% of hazelnut, respectively). Studies show that time and conditions of storage are critical factors affecting vitamin E levels. Storage may affect the vitamin E content due to oxygen, UV-light, and temperature as the most influencing factors. Also, the presence of PUFA facilitates lipid peroxidation and leads to a consumption of tocopherols. Vitamin E loss has been reported to vary substantially in different studies, including 10–30% losses in butter and ghee within 24 weeks. In addition, it has been shown that α -tocopherol generally decomposes faster than γ -tocopherol (Sundl *et al.*, 2007) concurring with results obtained in this study. Mallia *et al.* (2008) reported higher contents of α -tocopherol in UFA/CLA butter probably due to the cows' feed supplemented with sunflower seeds, which contain vitamin E. Also, α -tocopherol content decreased in both conventional and enriched butter types, after 6 weeks past of storage (Mallia *et al.*, 2008). In another study, Wojdyło *et al.* (2005) reported α -tocopherol reduction in conventional and fortified butter samples with polyphenolic compounds in skullcap roots (*Scutellaria baicalensis* Georgi) and procyanidins of the bark of hawthorn (*Crataegus oxyacantha*) during 28 days of storage.

Oxidative Stability

Oxidative stability of samples was determined through Rancimat. The stability of butter samples exhibited significant differences ($P < 0.05$) among fortified vs. control samples and was decreased by an increase in the amount of added hazelnut. The highest oxidative stability was observed for control while the lowest in the sample

containing 30% hazelnut powder (Figure 1). The lower oxidative stability of butter samples fortified with hazelnut powder may arise from the highly unsaturated fatty acid profile of hazelnut which affects the fatty acid profile of butter shifting it to a more unsaturated profile (Table 2).

Sensory Characteristics

Sensory profiles of butter samples during their storage are presented in Figure 2. As expected samples with higher hazelnut contents presented a more intense nutty flavor which also continued during their storage period. No significant difference in nut added butter samples ($P > 0.05$) was observed, as regards such undesirable flavor characteristics as acidity, rancidity, fishy, oxidised, and storage flavor. All the fortified samples were more spreadable and softer than control. Although, shininess of butter samples decreased significantly ($P < 0.05$) by the increase in hazelnut added amount, the overall acceptance was not significantly different ($P > 0.05$) between the fortified samples and control up to the fourth week of storage.

CONCLUSIONS

The study finally reveals that butter fortified with hazelnut powder can be introduced as a new and functional dairy product within the food market and that is because of its containing essential fatty acids as well as antioxidant compounds. It can

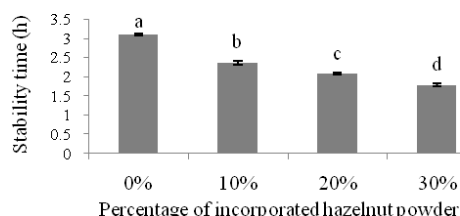


Figure 1. Oxidative stability of butter samples. Data are means of at least triplicate measurements. Error bars indicate SD values.

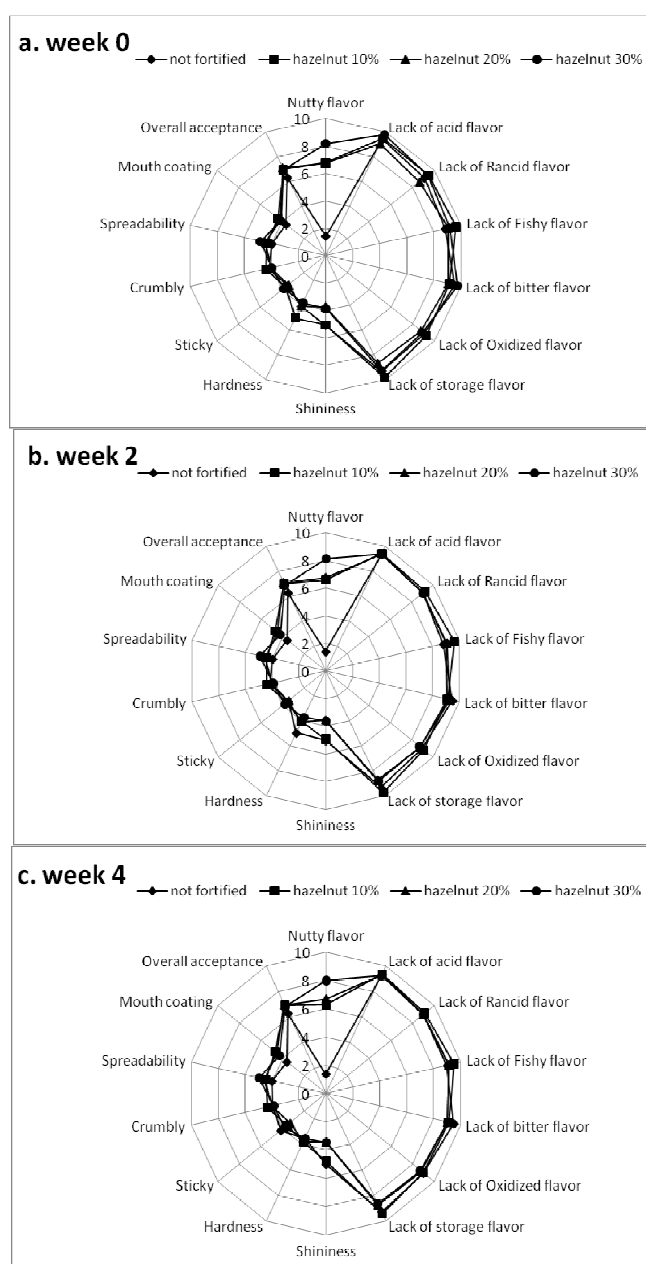


Figure 2. Sensory profiles of butter samples (a: Week 0; b: Week 2, c: Week 4).

play an important role in the health of consumers. In addition to nutritional benefits, addition of hazelnut can contribute to better spreadability in butter. The research also indicates that hazelnut incorporated butter is as stable as control, in terms of sensory and physicochemical qualities during its normal storage period.

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تولید کره حاوی پودر فندق

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چکیده

مصرف جهانی کره در طول دهه های اخیر به دلیل محدودیت های فیزیکی و خواص تغذیه ای ضعیف کره کاهش یافته است. در این بررسی، تاثیر افزودن فندق به عنوان منبعی از اسیدهای چرب غیراشباع و آنتی اکسیدان ها روی خصوصیات کره مورد بررسی قرار گرفت. فندق پودر شده در مقادیر ۱۰، ۲۰ و ۳۰ (W/W) به کره اضافه شد و نمونه های کره به مدت ۴ هفته در یخچال نگهداری شدند. عدد اسیدی و پروکسید، پایداری اکسیداتیو، پروفیل اسیدهای چرب، میزان توکوفرول و خصوصیات حسی نمونه های کره حاوی فندق مورد ارزیابی قرار گرفته و با نمونه کنترل در طول نگهداری مقایسه گردید. نتایج نشان داد که نمونه های کره غنی شده با فندق عدد اسیدی بالاتر و عدد پروکسید و پایداری اکسیداتیو کمتری نسبت به نمونه کنترل داشتند. مقادیر عدد اسیدی و عدد پروکسید در همه نمونه ها در طول



نگهداری افزایش یافت. غلظت اسیدهای چرب غیراشباع، شامل اسیدهای چرب ضروری به طور معنی داری ($p < 0.05$) در نمونه‌های کره غنی شده با فندق بالاتر بود. میزان α - و β -توکوفرول نیز در نمونه‌های غنی شده بالاتر بود، گرچه مقدار آن‌ها خصوصاً α -توکوفرول در طول زمان نگهداری کاهش یافت. ارزیابی حسی تغییر معنی داری بین نمونه‌های غنی شده و کنترل از نظر پذیرش کلی و ویژگی‌های طعمی نامطلوب نشان نداد ($p > 0.05$). این مطالعه یک فرآورده لبنی جدید را معرفی می‌کند که می‌تواند گامی به سوی اصلاح معایب تغذیه‌ای کره از طریق افزایش اسیدهای چرب ضروری و ترکیبات آنتی‌اکسیدانی آن باشد.